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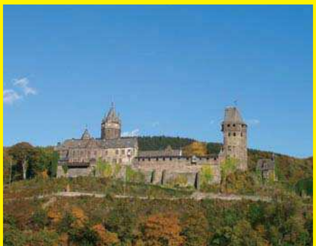

Optional practical evening classes

MFN Shot Peening Workshop in Germany
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Overhead Blast Cleaning and Shot Peening Systems

Evolution of automation

It has been almost a century since the introduction of the centrifugal wheel for blast cleaning applications. The need for this type of high-productivity cleaning device was driven by industry requirement to process large steel plates and structures prior to downstream coating processes such as painting and galvanizing. As a result, plates and structures started being processed in terms of meters per minute in an inline orientation, and with greater efficiency than the significantly slower manual cleaning means. Fast-forwarding the industry timeline by a few decades, automation in this industry evolved and has continued to do so with innovative techniques. Automation in centrifugal wheel type blast equipment is defined by one of two aspects – moving the part in relation to the blast wheel or moving the blast wheel in relation to the part, with the former more popular than the latter. Moving the part through the blast pattern generated by a single wheel or multiple blast wheels is achieved in many ways – using rollers, chains, overhead monorail, work car etc. Such work handling arrangements have been perfected to the extent that part feed rates and locations are accurately controlled and blast coverage optimized through the blast stream.

Common and custom automated machine styles with limitations

Automated blast equipment designs clean various geometries of parts. Simple Plate and Structural Steel Descaling systems are fitted with standard wheel layouts and for the most part considered commodities in this industry. The quantity and location of wheels have been standardized by most manufacturers for different part sizes. The calculation of wheel HP/KW has been validated empirically and practically in order to achieve required cleaning rates. However, when faced with custom fabricated sections or weldments, the story takes a slight twist. Quantity of blast wheels and their locations are determined in consideration to the result of their respective blast patterns relative to the intricacies in the part. Historically, in such applications, it is not uncommon to require some manual intervention to touch-up areas that remained inaccessible to the blast wheels. The desire to move the blast wheels during the cycle is countered by the complications associated with such a design, at least for conventional cleaning applications. As a rule of thumb, the length of the blast pattern is about the same as the wheel's distance from the part. Increased part-wheel distances though, increase the pattern length and adversely impact the intensity of blast, sometimes rendering the pattern ineffective. Therefore, the need to maintain a constant standoff distance from all part surfaces to the blast wheel was unmet with these fixed wheel machines. Increasing the quantity of wheels to address this issue was also not practical. Ultimately, not all parts were cleaned properly in such a machine. Greater issues were noticed in shot peening applications, where varying standoff distances resulted in incomplete part coverage and uneven transfer of impact energy. As the industry kept seeking solutions, automation in the airblast sector grew in leaps and bounds. Unlike blast wheels, nozzle movement was far simpler to achieve, in more than one way, using both nozzle manipulators and robots.

Use of blast nozzles in blast cleaning and shot peening

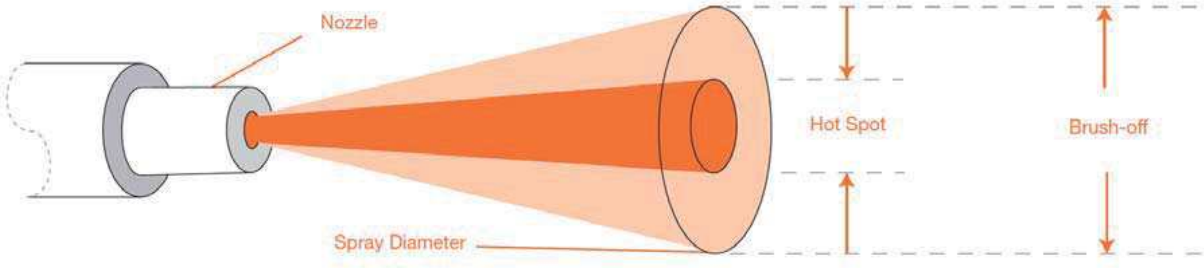
Blast nozzles have been in use for several decades, starting and continuing to this date, from manual cleaning applications to sophisticated shot peening machines in the Aerospace and Automotive industries. The nozzle itself has not evolved largely, with the traditional straight bore, a venturi style, and some minor variations of the two. In cleaning applications, nozzles are used in manual airblast rooms by single and multiple operators, in relatively lower production environments, and those that involve cleaning components with geometry that cannot be efficiently cleaned in automated equipment. The progress has been significantly rapid when considering the role nozzles have played in shot peening applications, particularly in the Aerospace and Automotive industries. Nozzles offer precision blasting, targeting and sensitivity to overspray which is prevalent in wheel type machines. Moreover, articulated movement of the nozzle(s) results in close to 100% coverage of all areas requiring impact of blast media. High precision components in Aerospace applications sometimes require blasting with non-ferrous media, which again is done most efficiently with blast nozzles. Nozzles are also more effective when accessing inside holes and slots, common features in aerospace applications. Air type media propulsion systems using blast nozzles are of two types – suction and pressure, each with its place in applications.

The choice of suction or pressure style media propulsion systems is determined by the distance of the part from the nozzles (compensated most times by nozzle movement) and the requirement for hot spot, particularly in peening applications. Pressure blast nozzles provide a more distinct hot-spot even at increased distances from the workpiece and are for that reason more commonly used in shot peening applications.

Use of some kind of nozzle manipulation with a robot or nozzle manipulator automatically multiplies the versatility of airblast systems. A case study is being presented here for review.

Case study – monorail style robotic airblast system

Note: This case study is presented by Empire Abrasive Equipment in Langhorne, PA (USA). Identity of the



Suction-Blast Spray Diameters

Nozzle ID	Distance from Workpiece 6"		12"		18"	
¼"	1⅜"	2⅝"	–	2¾"	–	1"
5⁄16"	1½"	3½"	1¾"	4½"	–	3¾"
7⁄16"	2"	3¾"	2"	4½"	–	3¾"

Brush-off Hot Spot

Pressure-Blast Spray Diameters

Nozzle ID	Distance from Workpiece 6"		12"		18"	
⅛"	¾"	1"	1"	1½"	–	1⅛"
3⁄16"	1¼"	1⅜"	1½"	2"	1⅝"	2½"
¼"	1¼"	1½"	1⅞"	2¼"	2⅛"	2¾"
⅜"	1⅝"	1¾"	2"	2¼"	2¼"	3"

Brush-off Hot Spot

end-user is protected for confidentiality reasons.

Application

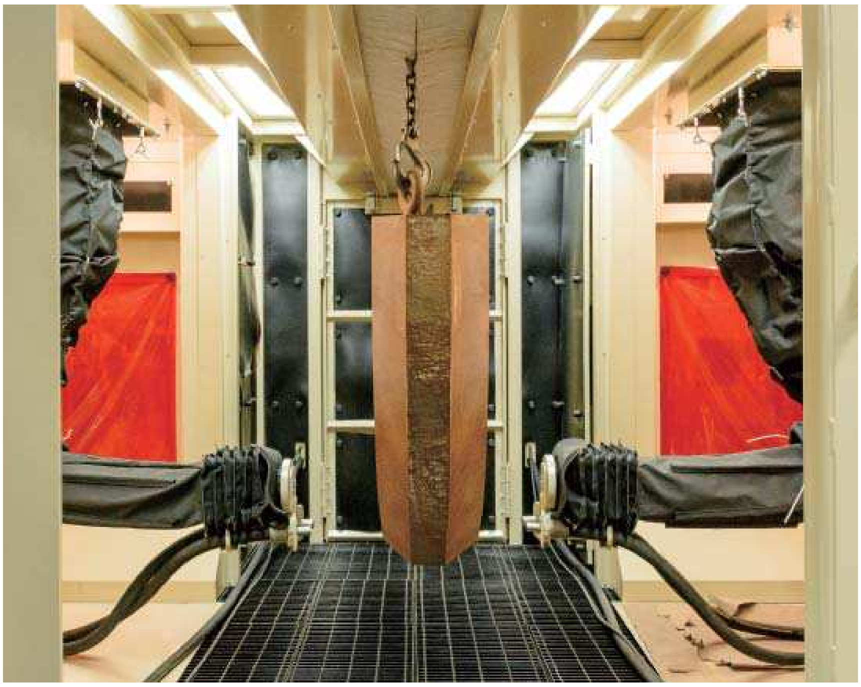
- Blast cleaning a component containing intricate geometry and internal passageways to remove rust, scale and other contamination prior to coating and as part of the refurbishment process.
- The part geometry and nature of disassembly prevented complete access to the part intricacies, specifically in areas where cleaning requirement was critical.

Solution brief

The solution involved two key elements, similar to earlier discussions – (a) part presentation to the nozzle(s) and (b) nozzle articulation to the part.

(a) Part presentation to the Nozzle – The part in question was significantly heavy and the application required blast coverage not only in the intricacies, but also on all exterior areas. This also meant that the fixture could not mask or shield any of the coverage areas. Therefore, the only effective means of "fixturing" the part was using an overhead conveyor/hook arrangement. In conventional overhead monorail style systems, the part passes through the blast stream with stationary wheels or nozzles. However, after a detailed assessment of the part style and nature of blast media, it was determined to keep the part fixed and instead move the nozzles. More of this is discussed in later paragraphs.

(b) Nozzle articulation, as indicated earlier, can be achieved using at least two different techniques – nozzle manipulators and robots. The choice in this case was determined in two steps – (i) giving consideration to part geometry and profile, and (ii) robotic simulation using RobotStudio. The use of RobotStudio is one of the first steps Empire undertakes when working on a robotic blast cleaning or shot peening concept. This software very accurately simulates



Overhead Conveyor Robotic Airblast Systems

Nozzles mounted on dual robots to simultaneously process both sides of part with complex geometry

robot arm articulation and predicts behavior in an actual production environment. In other words, not only does it help determine whether all part areas are going to be covered but predicts possible interferences with other machine and part elements as well. As a result, blast enclosure dimensions and shape can be accurately determined right at the conceptual stage.

The use of nozzle manipulators was not appropriate in this application. Intricacies in the part required a fourth and at times a fifth axis of nozzle movement, not so easily achieved using a manipulator. Moreover, sealing arrangements with as many axes would have also been complicated with nozzle manipulators. Commercially available robots satisfied all the needs of this application and provided the flexibility to the end-user to re-teach nozzle paths if their part needs changed in the future.

Other design considerations

- Media reclaim system: The blast cleaning process required the use of very fine aluminum oxide as the abrasive. Also, tolerance on the final surface finish was tight. This required the use of media quality maintenance using a fine-tunable reclaimer and a vibratory classifier with two screens. Blast pressure being the other variable in achieving repeatable surface finish, the blast tank was provided with a closed feedback loop to ensure constant blast pressure throughout the cycle.
- Touch-up: The end-user was making a quantum leap in process with this new machine. They were transitioning from a completely manual process with very little process control to a computerized, robotic blast system. The skepticism among the operating staff was evident, and Empire addressed this by providing a manual touch-up station within the same cabinet and share-linked the same reclaim system to ease their concerns.
- Cabinet Sealing: Given the high breakdown rate of blast media, Empire designers decided to completely seal and interlock the blast operation using two doors at both ends. This resulted in a fixed ventilation volume, calculated using ACGIH norms, to ventilate the cabinet during the blast process and minimization of media/dust leakage from the cabinet.
- The system was supplied with computerized controls for the operator to teach, store and retrieve part recipes/techniques. The in-house controls team at Empire partnered with the end-user to ensure that the HMI was user-friendly and the screens designed for added familiarity to the operator.
- Though actual figures cannot be published due to reasons of confidentiality, this robotic system satisfied two of the end-user's most important criteria – (1) reduced their cycle time to a fraction of current cycles to clean these components, and (2) provided consistent cleaning quality and surface finish, without the need for touch-up for majority of their parts.

Other applications using the same technique

Overhead conveyor systems in conjunction with robotics have established a niche presence in Empire's product portfolio. Such a solution is adopted for more than just cleaning intricate areas. When shot peening aero structures, such an arrangement ensures that ribs, stiffeners, chords and similar features on structures are all targeted at the same stand-off distance and resulting impact energy. In addition to fixed part orientation, Empire systems also accommodate pass-through movement of parts with robot arms accurately locating part surfaces to target.

Overhead conveyor style systems also offer a distinct advantage over horizontal conveying in terms of minimizing media accumulation and carryout in pockets and crevices, commonly seen in aircraft structural components.

Conclusion

Airblast systems are not commonly seen using overhead monorail for part conveyance. However, looking at the inherent advantages, it is certainly worthy of consideration. Rightfully so, the majority of users of cleaning and peening equipment focus on the process and leave the choice of work handling to the supplier. Therefore, it is incumbent on the supplier to educate the user on all possible methods of work handling to ensure the process achieves maximum operating efficiency.

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